Problems of Performance Measurement in Locally-Organized Systems

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ABSTRACT

It is shown that many of the modern intelligent systems belong to a wide class of distributed systems. The external behavior of such a system is governed with criteria which induce only partial ordering among various systems. This partial order does not allow building an analytical metrics in the space of such systems, the fact making systems largely indistinguishable. This explains the existence of many versions of AI systems made for the same purpose, like Expert Systems shells, which are frequently differentiated only through their secondary properties. The situation may be compared with that of the use of Pareto sets in theory of games where all different solutions belonging to a Pareto set are considered to be intrinsically similar.

KEYWORDS: *distributed systems, performance metrics*

1. INTRODUCTION

Practical considerations do require introduction of some metrics to measure system performance. If a scalar value is used to estimate the performance it is quite natural to define a metrics based on this scalar. In some cases there are some serious grounds for this. The information throughput [1], an average income obtained in the system for Stock Exchange trend forecast may be considered as examples of the scalar valued system.

However when the performance is measured by a vector value it obviously brings some additional problems. In the simplest case a weighted vector is used reducing the problem to the scalar type formulation. However in many cases it is impossible to find weights uniformly suitable for the whole performance space like the distance measure in an Euclidean space. It is for this reason some other "optimality" considerations are used like Pareto sets in Game Theory [2] and in many other applications (in particular, in Mathematical Economics.)

2. DISTRIBUTED SYSTEMS

Another wide area where the search for a performance metrics is doomed to failure, and which will be discussed in this presentation, is the area of distributed systems, referred here to as the locally-organized systems (LOS) [3, 4]. We use the latter term in order to emphasize the fact that in such systems a unique common measure defining the whole system performance does not exist. Instead, one has a collection of local criteria for the system components [5], which are used concurrently and individually and hence can not be reduced to a unique scalar or vector value.

The exact meaning of notions, used in our description of locally organized systems depends on the subject domain. However it is possible to demonstrate some classes of models for which the situation is known in advance:

- The subsystems are deterministic or probabilistic finite automata with the deterministic or probabilistic interaction (collective behavior, collective behavior of automata, automata games)
- Subsystems are automata with the continuous sets of actions with the interaction of deterministic type (multiple access communication systems, sociological and economics models).
- Subsystems are finite automata with a fuzzy interaction (Expert Systems).
- Subsystems are the enterprises or individuals who are involved in a complex monetary and commodity circulation.
- Inhomogeneous technical systems, where people are also involved (man-machine systems).
- Subsystems are interacting programming modules (interactive high level languages, Artificial Intelligence systems).

Anyway, probably due to some practical considerations, many distributed systems of this kind are treated as centralized ones allowing some metrics for the whole system

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performance. Thus, in the majority of multi-agent systems [5] there exists a central point collecting all the information from agents and assigning tasks to the individual agents. It is important to note that such a centralization is out of question for LOS.

The proposed presentation will be organized in the following way. First, we will introduce a formal definition for LOS. Then we will list the reasons why LOS becomes a necessity in many applications, later describing the methods typically used for analyses and study of LOS.

We still are able to speak about "goals" for LOS. However the goal of the locally organized system (LOS) is the provision of a normal functioning of its subsystems, instead of reaching a certain system goal. That is why the criteria for the choice of an adequate system version may include such considerations as *expediency*, *survivability*, *openness*, *elasticity* and etc., which have been studied in many applications and in many subject domains [6] and which will be briefly reviewed in our presentation. Any of the above criteria may take only one of two values Yes/No or 1/0. Obviously, the induced partial order gives only limited possibility to compare systems.

The mentioned criteria are subject to changes from one group of problems to another still having the property that they do not allow to compare systems by introducing any reasonable metrics to supplement the above step-wise partial order. A number of examples will be listed - from collective behavior to manipulator control and interacting programming modules of an Artificial Intelligence system. This list and other considerations will demonstrate that the fraction of systems belonging to the class of LOS will probably only grow with time.

Finally some mathematical models of an intelligent warehouse [7] are used to illustrate the whole approach in a step by step manner.

3. CONCLUSION

As many of the modern intelligent systems are organized in a local way, being collectives of interacting components each having its own goal and behavior, our results show that it is not simple to find a suitable metrics for measuring system performance to be used for making a comparison among intelligent systems with respect to each other. Probably this explains the existence of many versions of AI systems made for the same purpose, like Expert Systems shells, which are frequently differentiated only through their secondary properties.

Our analyses is formal and strict. However it is supplemented with a practical example of an intelligent warehouse which admit different type of organization of storage place.

4. REFERENCES

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